Precision reference bans precision resistors

Budge Ing, Maxim Integrated Products, Sunnyvale, CA

COMBINING A SWITCHED-CAPACITOR charge pump with a precision reference yields an inverted reference from a positive power supply (**Figure 1**). Unlike the more typical combination of a positive three-terminal reference and an op-amp inverter, this circuit performs accurate inversions without the need for precision resistors and a negative supply. The compact circuit requires only three surface-mount capacitors, and the ICs occupy tiny SOT-23 packages.

The charge-pump inverter, IC_2, delivers −5V by inverting the output of a 5V precision reference, IC_1. IC_1 has an input range of 5.2 to 12.5V. Replacing IC_1 with a 2.5V reference that accepts 2.7 to 12.5V inputs produces a −2.5V output.

Output-voltage accuracy depends partly on the initial accuracy of IC_1, which in this case is 1%. To determine the overall accuracy, you must add the error from the dropout voltage, which is less than 2 mV for 90 μA of load current (**Figure 2a**). For a −2.5V output, the circuit draws quiescent current that ranges from 86 μA for a 2.7V input to 105 μA for a 12.5V input. For −5V outputs, the circuit draws 127 μA for 5.2V inputs and 140 μA for 12.5V inputs (**Figure 2b**). (DI #2368)

To Vote For This Design, Circle No. 420

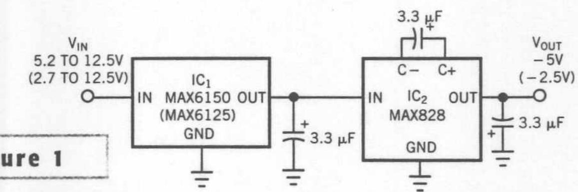


Figure 1

Combining a voltage reference and a charge-pump inverter forms a precision negative reference.

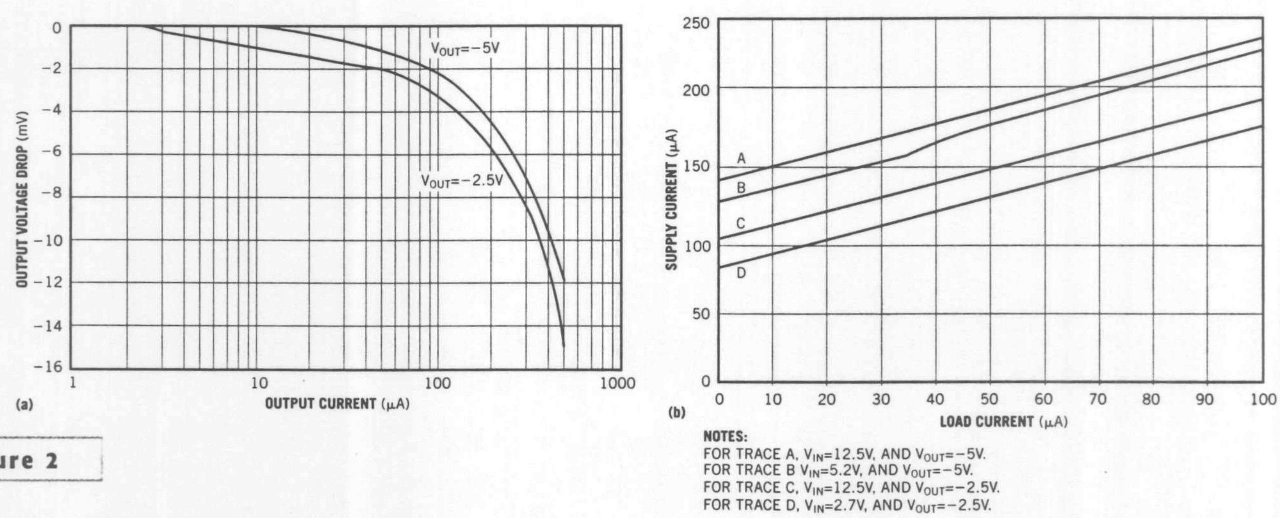


Figure 2

For a −5V output, the dropout voltage is less than 2 mV at 90 μA of output current (a). For a −5V output, quiescent current ranges from 127 to 140 μA.

Easy method calculates comparator trip points

Virgil Lawrence, Micro Linear, San Jose, CA

USING MILLMAN'S THEOREM to calculate the resistor ratio reduces the time it takes to calculate the trip points on a comparator with hysteresis. This method eliminates lengthy computations and substitutions. Using this resistor ratio, you select two resistors, assign convenient values, and then calculate the third value.

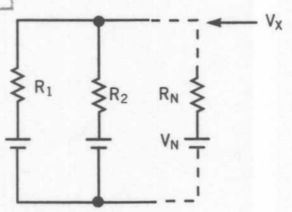
Assume an inverting comparator with an upper limit of 4V and a lower trip voltage of 1.333V. The voltage on the in-

verting input needs to reach 1.333V for the output to switch to V_{CC}. Then, for the output to return to zero, the input voltage needs to reach 4V.

Millman's Theorem states that the sum of the products of the voltages times their respective conductances divided by the sum of the conductances gives the common junction-point voltage V_X (**Figure 1**). Or,

$$V_X = \frac{\sum V_N G_N}{\sum G_N},$$

Figure 1



Millman's theorem states that the sum of the products of the voltages times their respective conductances divided by the sum of the conductances gives the common junction point voltage V_X.

where G=1/R.

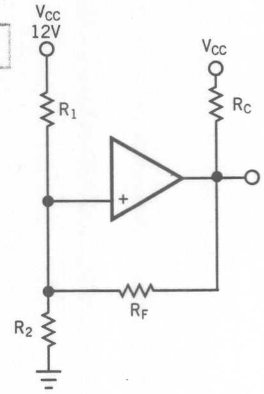
Using Millman's Theorem, with V_{CC} at the top of R_1 and R_F (**Figure 2**), set up the numerator with a Millman equation. Set up the denominator with another Millman equation when the output voltage is zero (with only one voltage source in the denominator). Assume that R_C is $<<R_F$ and therefore negligible in the calculations. The resultant equation for the voltage ratio is:

$$\frac{V_{IN(HIGH)}}{V_{IN(LOW)}} = \frac{\dfrac{\sum V_N G_N}{\sum G_N}}{\dfrac{\sum V_N G_N}{\sum G_N}} = \frac{\dfrac{12}{R_1}+\dfrac{12}{R_F}}{\dfrac{12}{R_1}}$$

$$= \frac{R_F + R_1}{R_F} = \text{VOLTAGE RATIO.}$$

This large fraction equals the voltage ratio 4/1.333=3. First solve for R_F in terms of R_1, and select R_1 in relation to R_F, such as R_1=1 MΩ, and R_F=500 kΩ. Then solve for R_2. The resistance ratio always equals the voltage ratio minus one. (DI #2372)

Figure 2



Using Millman's theorem, you can calculate that the voltage ratio of the trip points equals $(R_F+R_1)R_F$.

TO VOTE FOR THIS DESIGN, CIRCLE NO. 421